POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 26, 2005; Volume 26, 2005

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METASEDIMENTARY AND METAVOLCANIC ROCKS FROM NE POLAND AND LITHUANIA: IMPLICATIONS FOR PRECAMBRIAN CRUSTAL EVOLUTION

Abstract: The paper presents geological, petrogenetic, geochemical and geochronological features of several metavolcanic and metasedimentary rock complexes from Polish – Lithuanian cross-border, belonging to Masovian massif and mid-Lithuanian suture zone. On the basis of the regional geophysical images and geochemical characteristics of the studied rocks we suggest that mid-Lithuanian suture zone structure continue to NE Poland, namely in the Łomża-Mońki area.

Keywords: geochemistry, U-Pb geochronology, Proterozoic, terrane, mid-Lithuanian suture zone

INTRODUCTION

The geology of Precambrian crystalline basement in Poland and Lithuania, completely covered by Phanerozoic sedimentary units, has been studied by geophysical and boreholes surveys from early 60-ties of the 20th century. The first concept of Prekarelian granitoid massifs, as Mazovian, Dobrzyń and Pomerania, and Prekarelian metamorphic folded zones in Poland (Ryka 1984) was modified at the end of ninetieth (Ryka 1998). From that time Palaeoproterozoic granitoid-gneissic massifs of enigma provenance and age, surrounded by metamorphic folded structures had been described. Lack of proper radiometric data, which would confirm different age data of rocks in massifs and folded complexes was for geologist the main problem for a long time. We report here the preliminary results of geochemical and geochronological studies of crystalline rocks drilled from the Mazovian massif area (*sensu* Ryka) and similar metasedimentary and matavolcanic rocks from Lithuanian cross-border, and consider their implication for geotectonical setting and terrane concepts in SW part of East European Craton (EEC).

GEOLOGICAL BACKGROUND

The Łomża–Mońki (L-M) area represents the so-called Mazovian massif in northeastern Poland. This geological structure was distinguished mainly on the basis of the monotonic gravimetric and magnetic images. However, a new regional, geophysical

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approach (Królikowski, Petecki 2000) has evidenced clear continuation of mid-Lithuanian suture zone (MLSZ) and West Lithuanian (WL) domain to NE Poland, just in the L-M area. The rocks recovered from Łomża IG-2 borehole have shown predominantly orthoamphibolite, gneiss and schist, which are the record of Late Paleoproterozoic (1.80 Ga) subduction-related mafic igneous activity (Krzeminska *et al.* 2005), whereas in Mońki IG-2 borehole, 800 meters of grey gneiss and 100 meters of schist on the top were encountered. The Mońki gneiss has classically been interpreted as terrigenous sequence (Wołkowicz 1996). Petrographic observations have indicated that the rocks are mainly volcanogenic, and they comprise various lithological varieties, including mafic to intermediate metavolcanics, tuffogenic, metavolcaniclastic rocks and metagreywackes. The occurrence of similar rocks have been predicted in the area belonging to the MLSZ. This structure, N-S oriented, *ca*. 30-50 km wide, juxtaposed two main Lithuanian domains: West Lithuania (WL) and East Lithuania (EL). Crust thickness in MLSZ changes from 42-44 km in the west to 50 km in the east of this zone (Skridlaite, Motuza 2001). It is possible that WL and EL were joined during the final closure of the Svecofennian ocean at *ca*. 1.82-1.79 Ga (Mansfeld 1997), however, the metamorphic rocks studies and isotope data have pointed out that both domains developed separately until *ca*. 1.71-1.66 Ga.

Crustal discontinuity in transitional MLSZ is marked by tectonically engaged mafic and felsic intrusions. In general, the metasedimentary-metavolcanic rock sequence is intruded by Mesoproterozoic AMCG suite of the Mazury-Veisiejai complex. In the Lazdijai-32 borehole, the log is composed of garnet-biotite gneiss and clinopyroxene amphibolite alternating with granitoids. The Lazdijai-13 log consists of few centimeter to several meter thick layers of mafic and intermediate metavolcanics, alternating with variable metasedimentary gneisses and schists as well as with layers of marbles. Most of these rocks are affected by ductile and later brittle deformation. Likewise, southern part of WL is built of metasedimentary series with subordinate felsic and intermediate metavolcanic rocks, well known from several boreholes in central Lithuania. In the Virbaliskis-434 borehole porphyritic metavolcanics of intermediate composition dominate, as well as in Bliudziai-150 core (west from the Virbaliskis-434 borehole) which contains a several hundred meters thick metavolcanic-metasedimentary sequence with veins or lenses of anatectic granites, but in Pilviskiai-140 porhyritc meta-igneous rocks have been found. The position and nature of MLSZ, meant as the boundary between independent terranes: WL and EL, is not well constrained geologically as yet, however, many features suggest the volcanic island arc tectonic setting of this domain.

GEOCHEMICAL CHARACTERISTIC

The textural and petrographic composition of Mońki gneisses is reflected by SiO_2 different content: mafic metavolcanics (46-47 %), metavolaniclastics (55-63%) to metaquartzite (78-90%). The PM-noramalised trace element patterns for Mońki metavolcanics and metavolcaniclastic are generally similar to each other, except the LILE part. However, the diagram characteristics based on mobile elements must be interpreted with caution. Fig. 1 presents abundance pattern for Mońki gneisses compared to its equivalent pattern for MLSZ metavolcanics. Starting from immobile elements, they clearly show the similar distinctive spiked pattern, stressed by important Nb negative anomaly.

In geological processes, such elements as Th, Sc, La, Zr, Nb, Y, Ti, were usually transferred quantitavely from source to sediments (Bhatia, Crook 1986; McLennan *et al.* 1993). The ratios of Th/Sc and Zr/Sc, which are inherited intact from the source region and therefore reflecting petrogenetic evolution (McLennan *et al.* 1993), were used to compare

with studied rocks from Poland and Lithuania (Fig. 2). They form a typical volcanic rock sequence from high-alumina basalts (HAB) through low-silica andesite (LSA), andesite (AND) and dacite (DAC) to rhyolite (RHA), and testify to the presence of

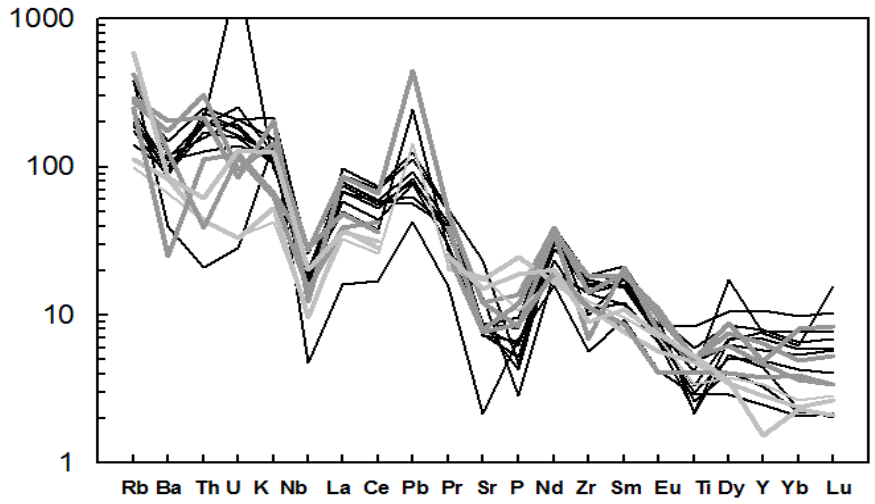

Fig. 1. Primitive mantle-normalized incompatible element pattern for Mońki gneisses (black colour) and for metavolcanics from Lazdijai and Bliudziai (grey colour).

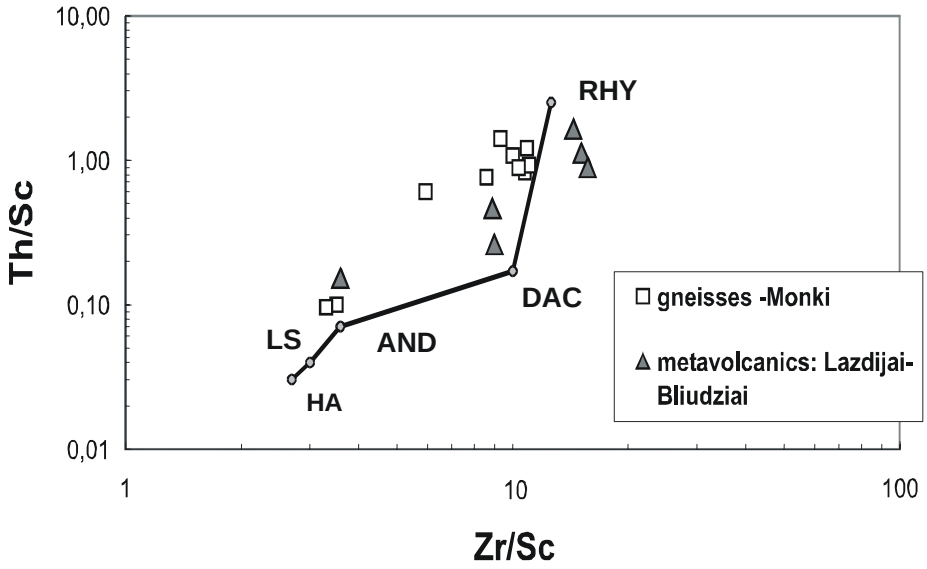

Fig. 2. Th/Sc-Zr/Sc diagram (*after* Mc Lennan *et al.* 1993) for Mońki volcanogenic gneisses and Lazdijai, Bliudziai metavolcanics. Linked are average values of volcanic rocks from high-alumina basalts (HAB) to rhyolite (RHY).

volcanogenic type material. On the Th/Sc–Zr/Sc diagram, the Mońki data cluster near the AND and predominantly DAC-RHY averages. The metavolcanics belonging to the MLSZ, show a similar trend. In addition, major-element variation diagram using the discriminant function of Roser and Korsch (1988) was examined. Seven major elements are designed to

discriminate between four main provenance groupings: mafic, intermedite, felsic and recycled quartzose. Investigated Mońki, MLSZ and WL samples cluster in mafic to imtermediate and minor felsic fields, that would be characteristic for basin developed on volcanic arc or active continental margins. The transition from mafic to felsic volcanism and volcaniclactic material could simply reflect arc evolution.

ISOTOPE AGE

U-Pb analyses of the zircons were performed using SHRIMP ion microprobe at ANU in Canberra and using SIMS (NORDSIM) at the Museum of Natural History in Stockholm. The zircons from Łomża orthoamphibolite consists of simple melt-precipitated grains with no visible inherited cores or metamorphic overgrowths. Their weighted mean $^{207}Pb/^{206}Pb$ age of 1802 ± 9 Ma is therefore interpreted as the emplacement age of the igneous protolith of the orthoamphibolites (Krzeminska *et al.* 2005). Preliminary U-Pb zircon ages for two samples from Mońki gneisses indicate predominant Paleoproterozoic ages overgrowth. The samples originated from metasedimentary rocks with typical inherited core, gave a very large range of core composition, with several group of ages. However, the sample from metavolcanics gave very consistent ages from igneous Paleoproterozoic component. In case of MLSZ rocks, the rounded zircons from the Lazdijai-32 anatectite yield ages in a range of 2.9-1.5 Ga. One detrital grain with well pronounced oscillatory growth patterns was dated at 2.91 Ga while the group of faintly zoned grains gave ages of *ca*. 2.00 and 1.94 Ga. One 1.94 Ga old core is overgrown by a wide *ca*. 1.50 Ga rim. More zircon groups were distinguished among the Bliudziai-150 detrital zircons. The oldest, oscillatory zoned two cores were dated on 3.08 and 2.88 Ga. Numerous zircon cores gave *ca*. 2.00, 1.94 and 1.89 Ga ages. Most of cores are surrounded with thick *ca*. 1.85 Ga rims. The Virbaliskis-434 porphyritic metavolcanic is of *ca.* 1.84 Ga.

CONCLUSIONS

Geophysical data images and drill core detailed observations have confirmed a continuation of MLSZ to NE Poland, just in Łomża-Mońki area. The geochemical data suggest that the volcanogenic and volcaniclastic-rich gneisses from Mońki and metavolcanic rocks from MLSZ reflect the same Paleoproterozoic (1.83-1.85 Ga) arc related volcanic activity. Observed transition of geochemical signatures from mafic to felsic and younging the ages to the south could simply indicate arc evolution. Fragments of this arc system was mentioned by Skridlaite and Motuza (2001), and named a middle Lithuanian volcanic arc (Motuza, 2004). The described Polish-Lithuanian comparison studies drastically changed view on the geological and structural model of the M-L area proposed by Kubicki and Ryka (1982), *i.e.* on the former Mazovian massif in Poland.

The research work was supported by the grant of KBN No. 2P04D 055 27

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